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IMPROVED STERILIZABLE MULTIPLIER PHOTOTUBES

Quarterly Progress Report for the Fifth Quarter

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by

Electro-Mechanical Research, Inc.
Photoelectric Division
Princeton, New Jersey

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E. J. Dumas
Project Engineer

M. Rome, Director of
Research and Engineering

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NOTICE

1. Introduction

The objective of this program is to develop improved multiplier phototubes with visible response for use in applications requiring sterilization. These multiplier phototubes are primarily intended for use in scintillation counting.

In the course of a previous contract a multiplier phototube with visible response was developed which could survive at least three cycles of dry heat sterilization with only moderate degradation in photocathode sensitivity. Some sacrifice in photocathode sensitivity was made to improve stability and prevent high photocathode resistivity.

The first approach taken in the present program was to study high sensitivity bialkali photocathodes on conductive substrates. The substrates were used to eliminate problems due to high resistivity of the photocathodes. This approach was not fully successful because interaction between the photocathode and the conductive substrate made it difficult to achieve high photocathode sensitivity consistently.

During this reporting period a new photocathode designated "NR" has been studied. This new photocathode has a high sensitivity and does not become resistive after sterilization. No conductive substrate is required.

2. Technical Progress

Four 541NR-01-14 photomultipliers have been processed and tested. Three of these have been through five sterilization cycles, and one has been through three cycles. The spectral response, gain, and resolution were measured for each tube. Results are discussed in the next section.

In the course of these experiments the resolution was worse than one would expect for the photocathode sensitivities observed. The resolution was improved significantly by replacing the scintillation crystal.

3. Test Results and Analysis

Test results on the four 541NR-01-14 tubes are summarized in Table I. The parameters of primary interest are the quantum efficiency, voltage required for 10^6 gain, and resolution.

The quantum efficiency at 4100 Å after the i-th cycle is reported as Q_i in percent rounded to the nearest whole number. The relative error in measurement from cycle to cycle is less than ten percent of the reported value. The ratio of quantum efficiency after the i-th cycle to the initial quantum efficiency Q_o is given in each case and is the clearest indication of the behavior of the photocathode sensitivity. A tabulation of these ratios in Table II for the sample of four tubes shows that tube D10068 differs significantly from the other three tubes which are closely grouped. The grouping of the data in this way is not entirely arbitrary.

Tube D10068 was processed more than seven months earlier than the last three which may suggest some value in processing tubes in groups to reduce the gradual variations in processing parameters which cannot be closely controlled over long periods of time. A more thorough study of the tube processing records will be made.

On the basis of the results of the latest three tubes, a decrease in photocathode sensitivity of approximately 25% of the initial value can be expected after three cycles.

The last tube processed, D11026, was baked for an extended period on the vacuum system after photocathode processing in order to stabilize the photocathode sensitivity. This had no significant effect on the tube stability.

The resolution data in Table I are complicated by the replacement of the damaged scintillation cyrstal. A correlation of results can be made by measuring the resolution of one tube alone using a CRT light pulser. The resolution of the crystal can be calculated from this result.

The poor resolution observed for tube D11030 is a result of gain instability which was observed after the first and each succeeding cycle.

4. Technical Difficulties

The NaI(Tl) scintillation crystal was found to be defective and was replaced by a new unit. This presents an added task of measuring resolution of a phototube alone so that the resolution of the crystal can be calculated. The results can then be correlated. This is not a difficult procedure, but it will introduce a slightly greater uncertainty in the resolution data.

An instability in gain was observed on tube D11030 after the first and each subsequent cycle. This gain instability was characteristic of tubes with excess residual gas. This may be a result of contamination of the tube envelope during assembly.

5. Planned Activities for the Next Reporting Period

The developmental phase of the program is complete. The processing procedure used for the 541NR-01-14 multiplier phototubes will be used to process the final test sample when EMR receives approval from JPL. A request for approval accompanies this report.

TABLE I

Summary of Test Results on 541NR-01-14 Sterilizable Multiplier Phototubes

Tube No.	Test	Q_i(%)	Q_i/Q_o	$1 - Q_i/Q_o$	V_i(Volts)	R_i(%)
D10068	0	27	1.00		2700	8.1
	1	21	0.78	0.22	2850	9.0
	2	18	0.67	0.33	2940	9.2
	3	14	0.52	0.48	2860	9.9
	4	14	0.51	0.49	2860	10.2
	5	13	0.48	0.52	2800	9.4*
D11030	0	24	1.00		2520	8.9
	1	20	0.85	0.15	2460	9.9
	2	20	0.85	0.15	2560	10.2
	3	17	0.70	0.30	2520	11.1
	4	15	0.64	0.36	2500	11.4
	5	12	0.53	0.47	2480	10.8*
D11027	0	35	1.00		2280	8.8
	1	30	0.86	0.14	2240	9.1
	2	29	0.82	0.18	2220	8.2*
	3	27	0.78	0.22	2240	8.4*
	4	26	0.75	0.25	2220	8.5*
	5	24	0.69	0.31	2220	8.3*
D11026	0	25	1.00		2200	8.1*
	1	21	0.82	0.18	2160	9.0*
	2	20	0.78	0.22	2160	8.8*
	3	19	0.75	0.25	2160	8.7*

Q_i = Quantum Efficiency at 4100 Å after the i-th cycle.

V_i = Voltage for 10^6 gain after the i-th cycle.

R_i = Resolution after the i-th cycle (* denotes new crystal).

TABLE II

Summary of Q_i/Q_o for the Developmental

541NR-01-14 Multiplier Phototubes

i	D11068	D11030	D11027	D11026	Average
1	0.78	0.85	0.86	0.82	0.83
2	0.67	0.85	0.82	0.78	0.78
3	0.52	0.70	0.78	0.75	0.69
4	0.51	0.64	0.75	--	0.63
5	0.48	0.53	0.69	--	0.57